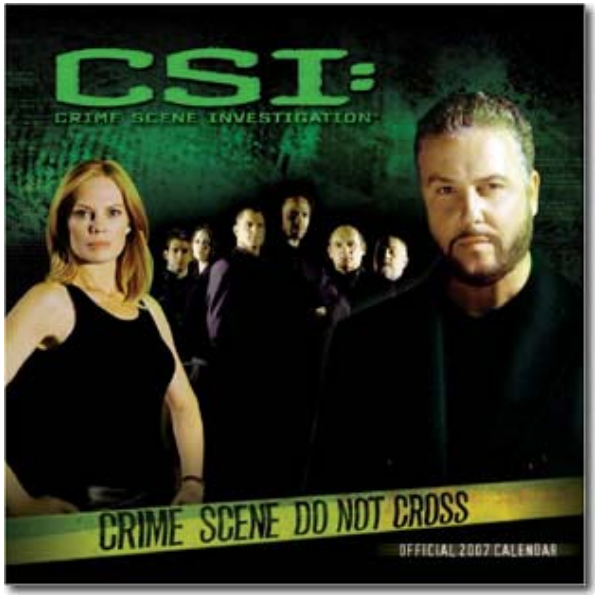
22 February 2007

14 Uranium Pellets found in a garden

Questions:

1. How did the material get there?
2. Origin of the material ?
3. Intended use of the material?
4. Age of the material?

Introduction



Atomic Detectives at Work: Providing Clues on the Origin of Seized Nuclear Material

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The Institute for Transuranium Elements (ITU)

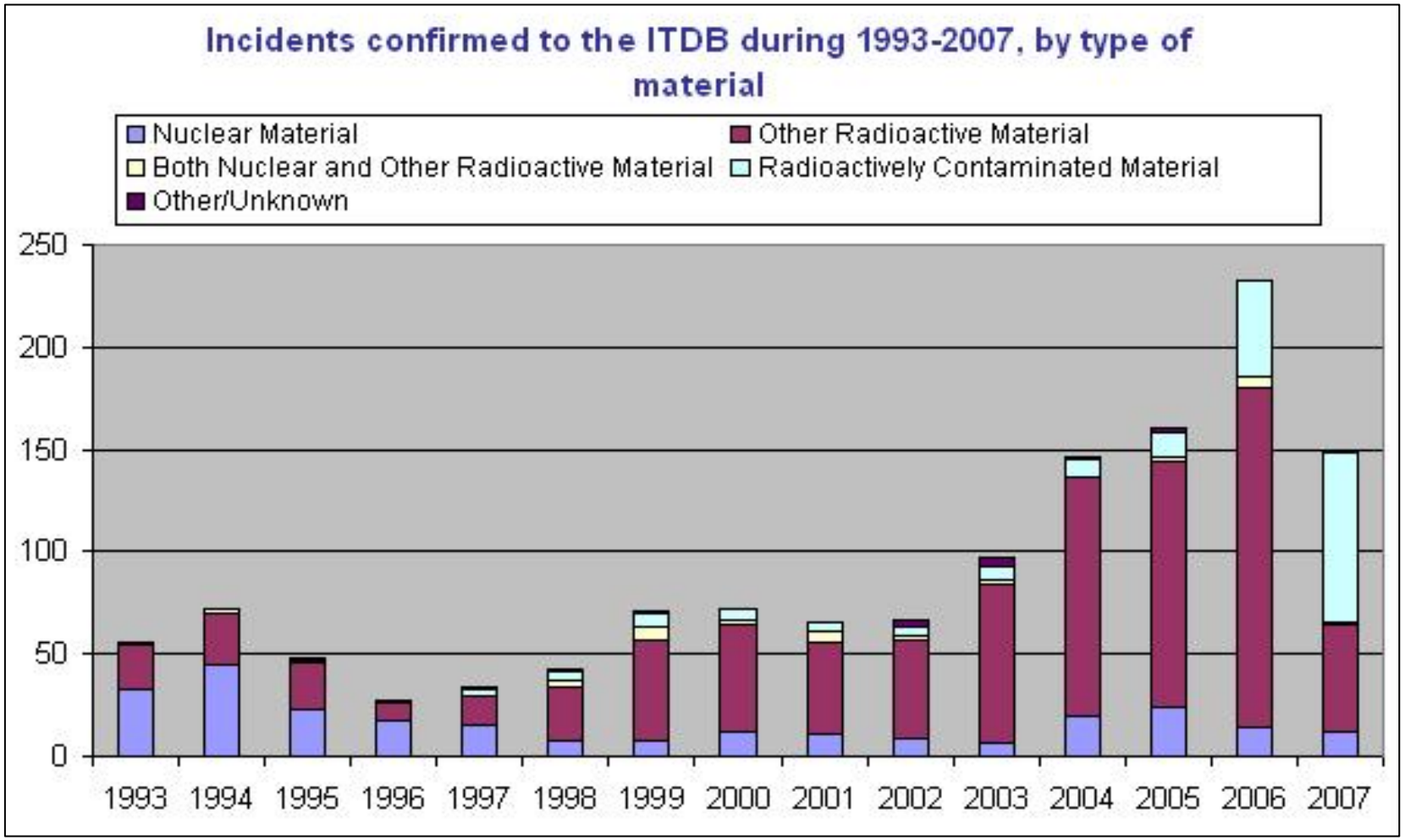
Commissioner Potočnik
Science and Research

- Joint Research Centre (JRC)
- Research DG (RTD)

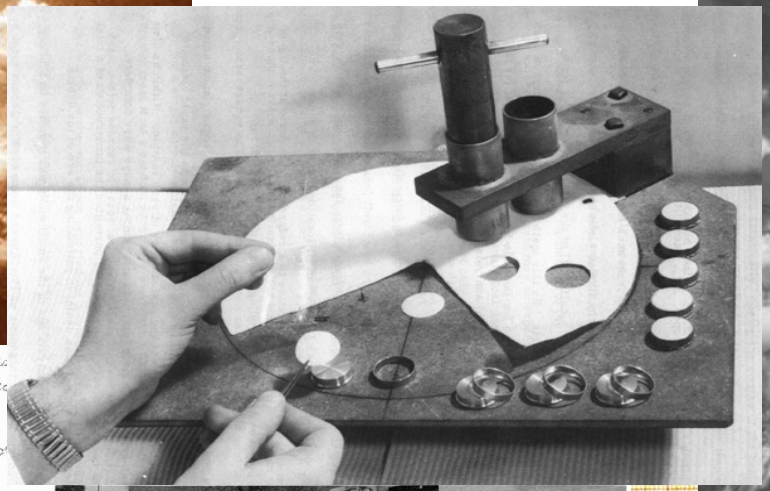
The mission of ITU is to provide the **scientific foundation** for the **protection** of the European citizen against **risks** associated with the **handling and storage of highly radioactive elements**.

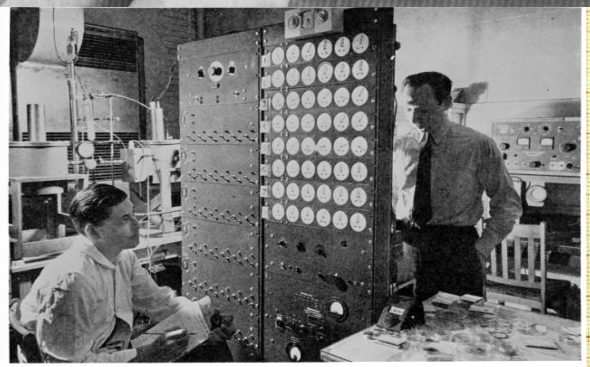
Illicit Trafficking (all types) incidents 1993-2007

(source: IAEA)

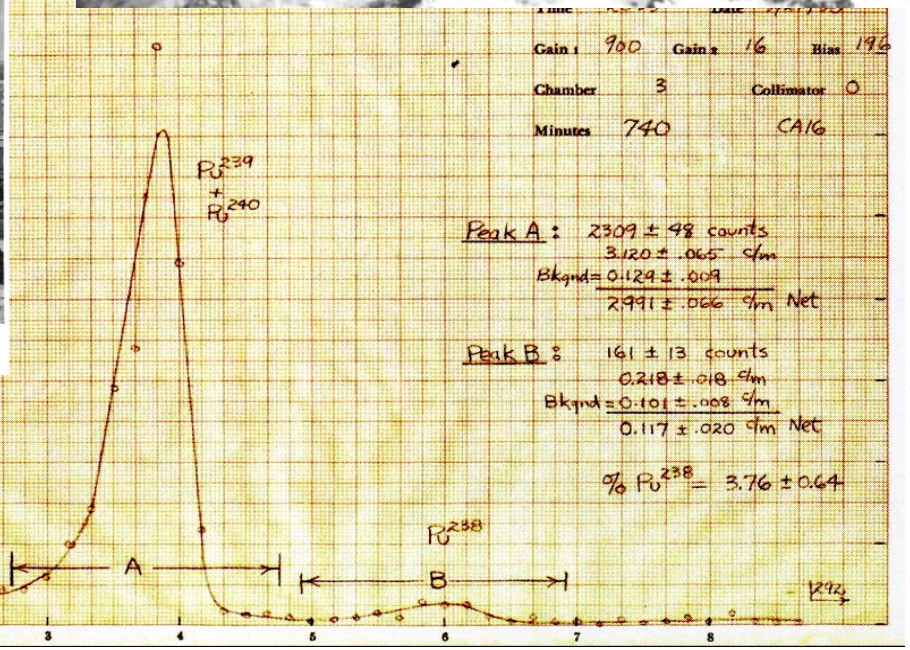


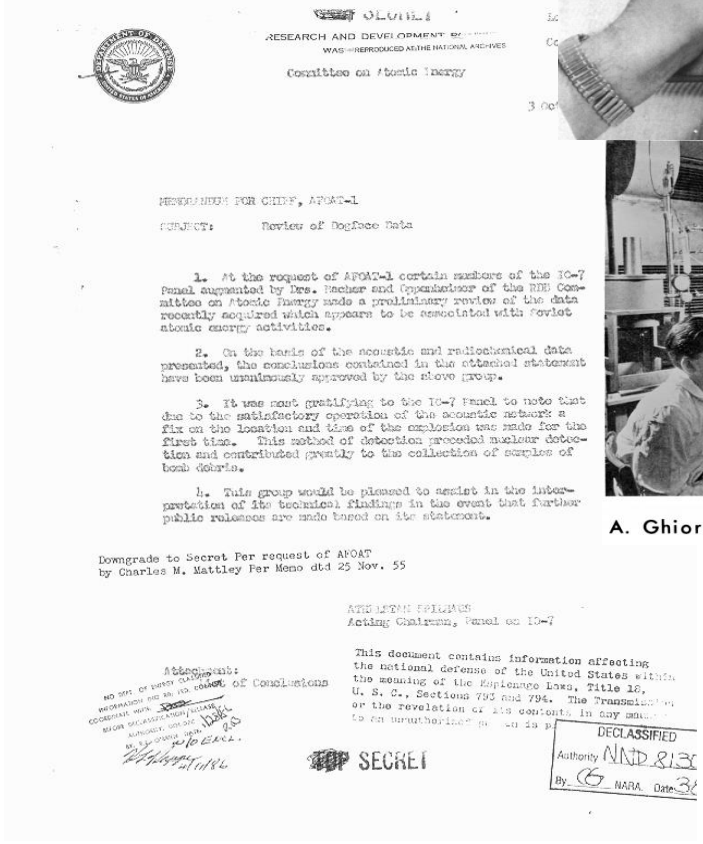
Nuclear Forensics – The early days





A. Ghiorso and A.H. Jaffey, New Chem, Jan., 1946.





RESEARCH AND DEVELOPMENT

Committee on Atomic Energy

MEMORANDUM FOR CHIEF, AFOAT-1

SUBJECT: Review of Dogface Data

1. At the request of AFOAT-1 certain members of the IC-7 Panel augmented by Drs. Bacher and Oppenheimer of the RDB Committee on Atomic Energy made a preliminary review of the data recently acquired which appears to be associated with Soviet atomic energy activities.

2. On the basis of the acoustic and radiochemical data presented, the conclusions contained in the attached statement have been unanimously approved by the above group.

3. It was most gratifying to the IC-7 Panel to note that due to the satisfactory operation of the acoustic network a fix on the location and time of the explosion was made for the first time. This method of detection preceded nuclear detection and contributed greatly to the collection of samples of bomb debris.

4. This group would be pleased to assist in the interpretation of its technical findings in the event that further public releases are made based on its statement.

Downgrade to Secret Per request of AFOAT
by Charles M. Mattley Per Memo dtd 25 Nov. 55

Acting Chairman, Panel on IC-7

Attachment:
Statement of Conclusions

This document contains information affecting the national defense of the United States within the meaning of the Espionage Laws, Title 18, U. S. C., Sections 793 and 794. The Transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

SECRET

DECLASSIFIED
Authority NND 813
By NARA Date

Response to illicit trafficking

Detection

Detection equipment, intelligence

Nuclear Material (U, Pu, reactor or weapons grade) or other radioactive material (^{60}Co,^{137}Cs, ^{192}Ir,…)

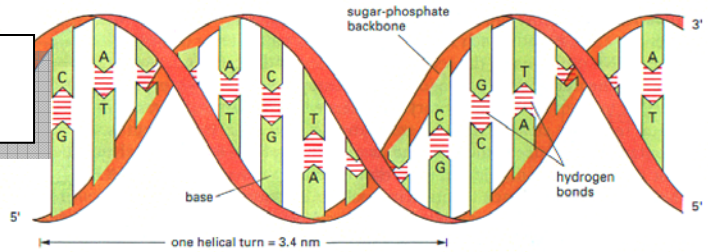
Categorization

Nuclear Forensics

Source Attribution

itu

Classical Forensics



Aims at identifying suspect **individual** using information adherent to the pieces of evidence:

- Fingerprints
- **"genetic fingerprint"**
- Fibre
- Hair
- Residues of explosives

Objective

Solve criminal case and put criminal individual to jail

itu

Aims at identifying origin and intended use
using information inherent to the (nuclear) **material**:

- Isotopic Composition
- Elemental Composition
- Impurities
- Macroscopic appearance
- Microstructure
- Decay Products

Objective

Improve safeguards and physical protection measures at place of theft or diversion to prevent future thefts or diversions

Nuclear Forensics Methodology

Analytical Methods
taken from:
- Safeguards
- Material Science
- Isotope Geology

Data →

- Isotopic Composition
- Elemental Composition
- Impurities
- Macroscopic appearance
- Microstructure
- Decay Products

Information

Exogenic
requires reference data

Place of Production
Last Legal Owner
Smuggling Route

Endogenic
self-explaining

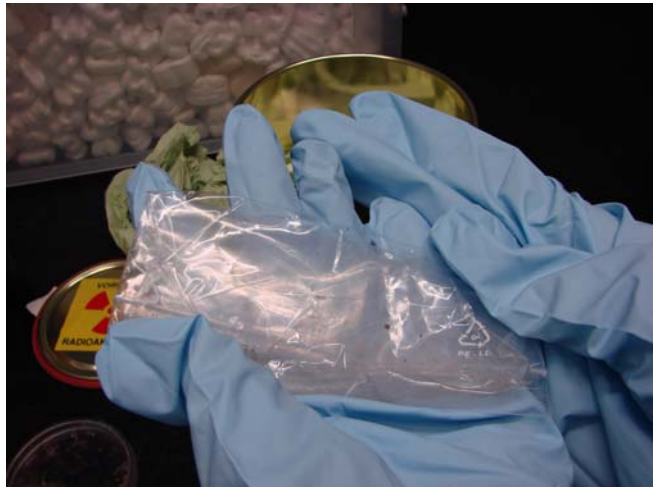
Age
Intended Use
Production Mode

Example Lauenförde -Chronology

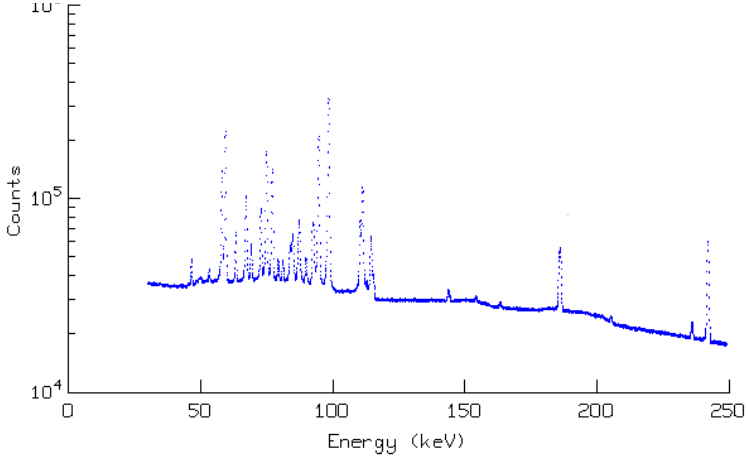
- 22. February 2007 Pellets found in garden
- 28. February 2007 Ministry for Environment (Niedersachsen) asks for support by ITU
- 03. March 2007 Samples arrive at ITU
- 05. March 2007 1. Intermediate Report (first clues)
- 09. March 2007 2. Intermediate Report (all conclusions)
- 10. Mai 2007 Final Report (full details)

Investigation in the Laboratory

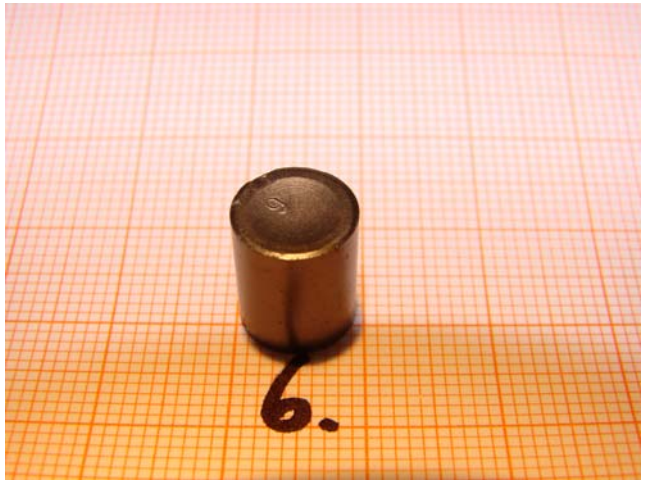
Unpacking



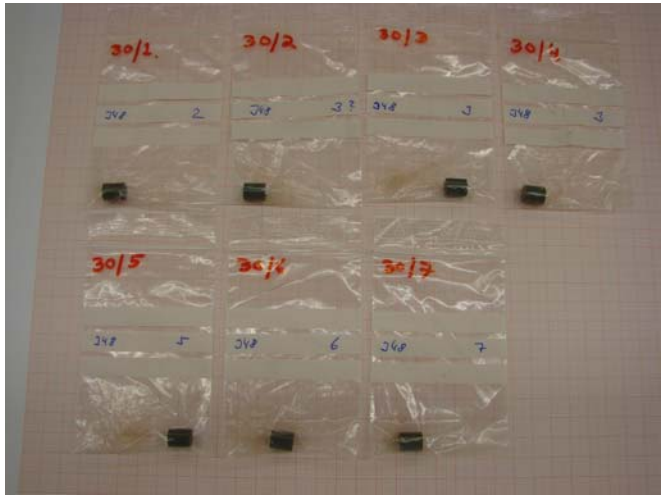
Non-destructive measurement



Visual Inspection



Homogeneity Testing



Isotopic Composition

measured by TIMS

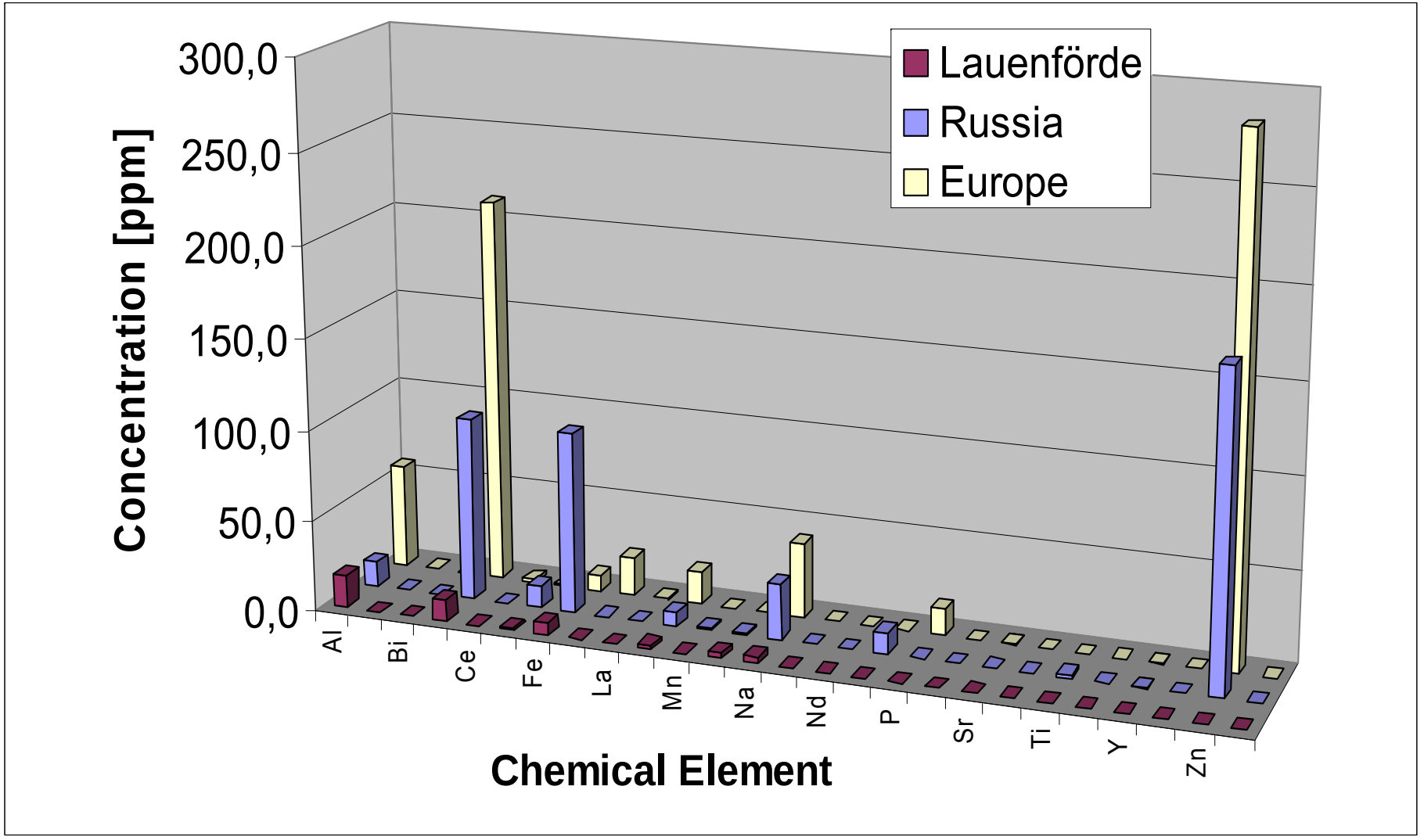
	U-234	U-235	U-236	U-238
Isotope Abundance (Mass%)	0,029 4 %	3,455 %	0,005 2 %	96,511 %
Uncertainty	0,000 3 %	0,004 %	0,000 1 %	0,003 %

measured by MC-ICP-MS

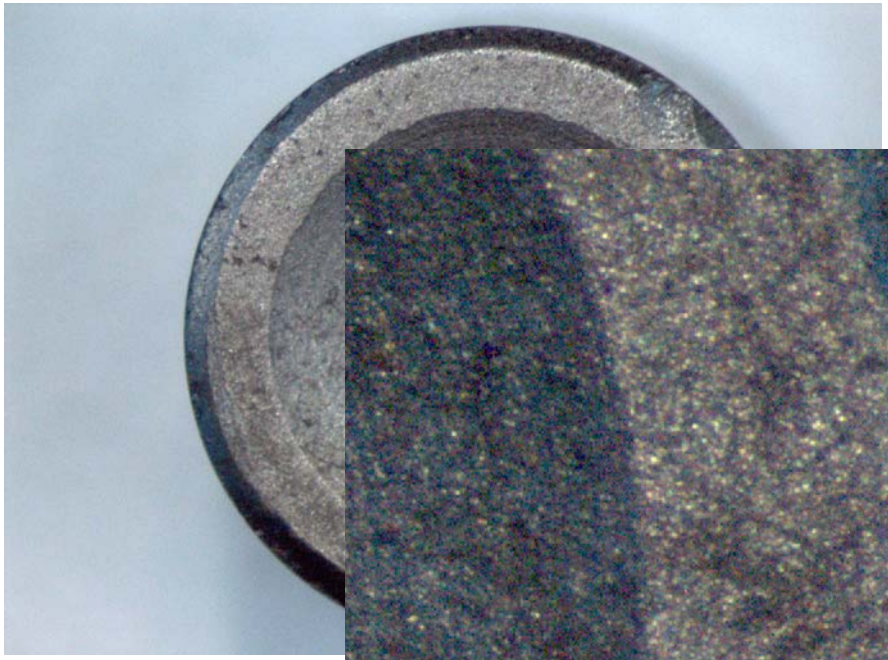
	U-234	U-235	U-236	U-238
Isotope Abundance (Mass%)	0,029 3 %	3,459 0 %	0,005 0 %	96,506 7 %
Uncertainty	0,000 2 %	0,002 0 %	0,000 1 %	0,003 0 %

Investigation in the Laboratory

Chemical Impurities



Investigation in the Laboratory



Optical Microscopy

Pellet Geometry

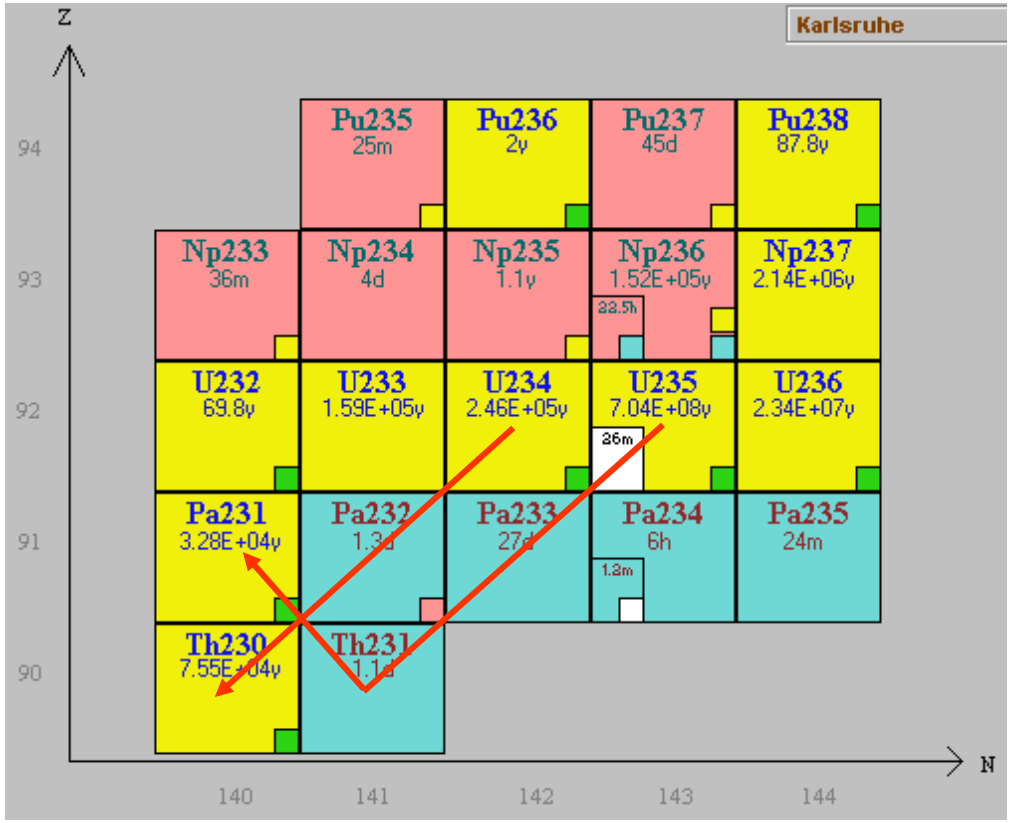
Database Query - Enrichment, Geometry

		Messung			Datenbank [1]		Datenbank [2]	
		Mittel-wert	StDev		Nominal-wert	Toleranz	Nominal-wert	Toleranz
Durchmesser	mm	9.26	0.02		9.11	0.02	9.11	0.02
Dishing Durchmesser	mm	**6.71**	**0.08**		**6.7***	**0.3***	6.73	0.05
Dishing Abstand (Land)	mm	**1.22**	**0.16**		**1.2**	**0.3**	1.2*	0.1*
Chamfer Breite	mm	**0.44**	**0.04**		**0.4**	**0.2**	*0.61*	*0.05*

Siemens (RBU) Brennelementfabrik Hanau

Age Determination

- Radioactive decay as built-in chronometer
- Last chemical separation Nov./Dec. 1990
- Pellet production campaign Feb./March 1991
- Fall 1991 Upgrade of physical protection at RBU plant



Example 1 - Conclusions

Pellets are

- Homogeneous
- Typical western European PWR Pellets
- Russian origin can be excluded
- Raw, unground
- Fuel fabrication plant in Hanau was identified as the only possible manufacturer
- Theft/diversion after sintering, before grinding

Example 2 Uranium Cube

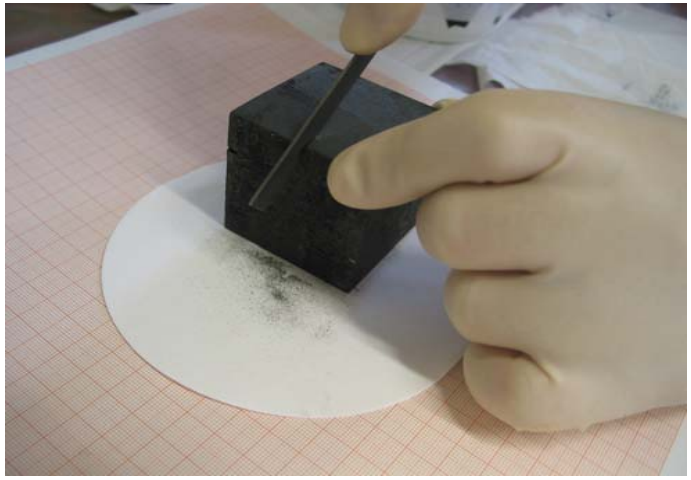
?

Nuclear Forensics -Examples

Origin and intended use ?

First observations/conclusions:

- geometry → 5 x 5 x 5 cm, unconventional application/reactor
- elemental composition → pure U metal
- isotopic composition → natural U → D_2O or graphite moderated reactor
- main impurities → Al, Ca, (Fe), Mg, Mn, Na, Pb, Si



Nuclear Forensics -Examples

1. Origin

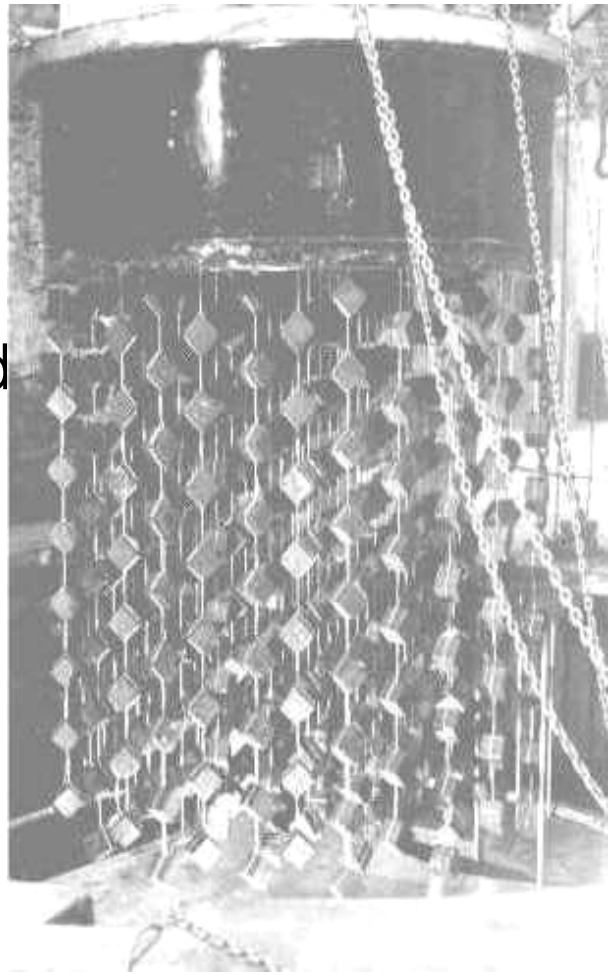
- Nuclear Materials Database

  – nuclear fuel data from western and Russian suppliers (UO_2, MOX) (based on World Nuclear Industry Handbook and bilateral contracts, various degrees of access)

- Electronic literature archive on non-conventional fuels (Russian sources)

- Open literature

<u>Geometry points at German origin</u>

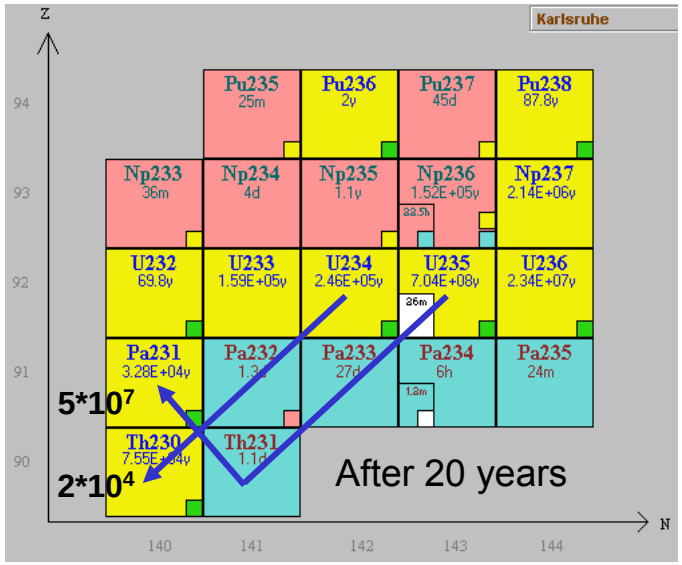


Nuclear Forensics -Examples

2. Age determination

- spiking with ^{228}Th (or ^{233}Pa)
- chemical separation
- measurement: alpha spectrometry or mass spectrometry

Age via ^{234}U / ^{230}Th



Age by ID-AS: 59.0 ± 1.5 years
=> Date of production: December 1943

Age by ICP-MS: 59.3 ± 2.0 years
=> Date of production: September 1943

Age indicates German (or US) nuclear programme

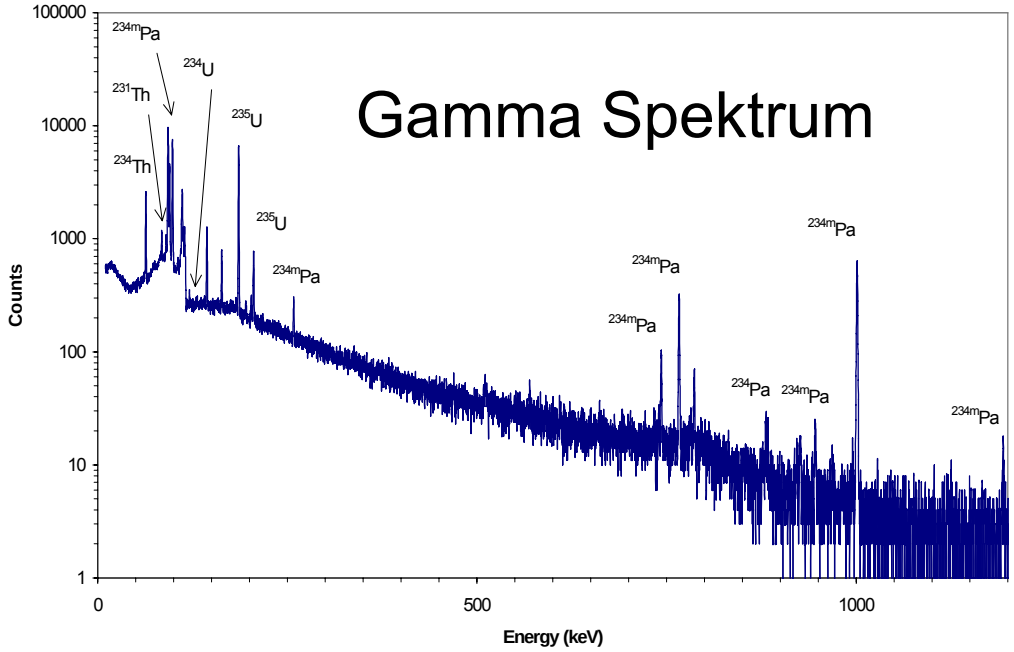
Nuclear Forensics -Examples

Was the reactor operational ?
If yes: U-235 + n → U-236, fission products, ….

3. Nuclidic information

Presence of ... ?

^{236}U, Pu, FP

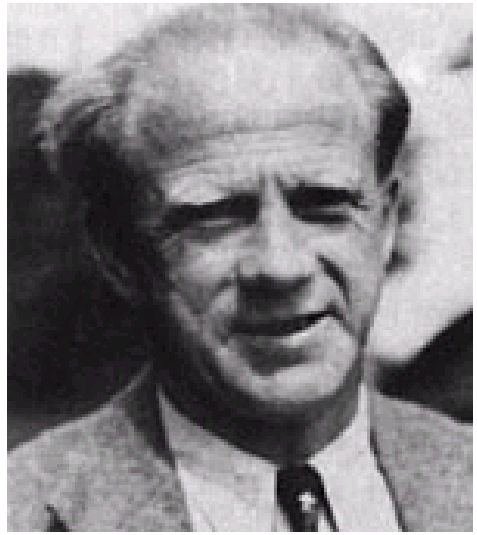


NO SIGNALS (within detection limits)

reactor was not operational

Werner Heisenberg

1901 - 1976



- Uncertainty principle 1925
- Professor at University of Leipzig 1927
- Nobel price 1932
- Professor at University of Berlin 1941
- Director of the Kaiser Wilhelm Institute 1942

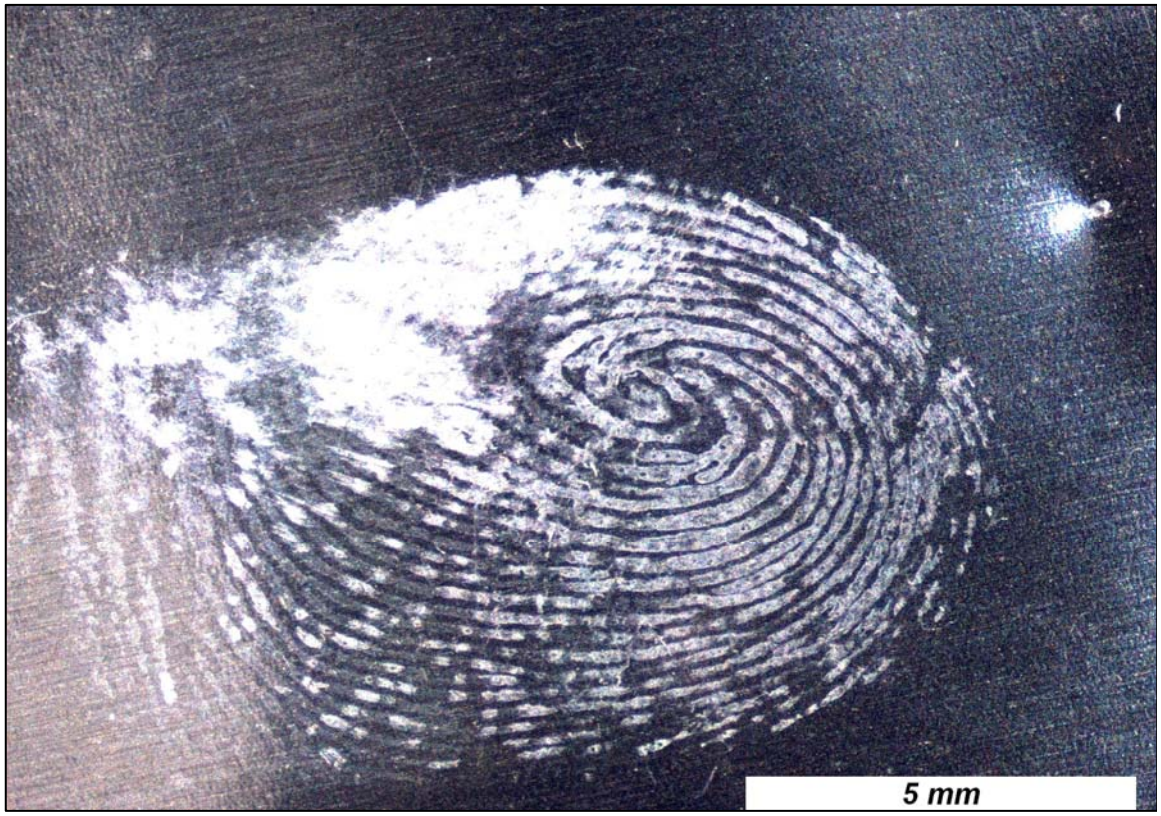
"Uranium machine"

659 cubes seized by Americans

5 cubes disappeared !!

Classical Forensics on Contaminated Items

- Cooperation with Police
  - Dedicated glove-box for taking fingerprints from contaminated items. Cyanacrylate Method
  - Procedures for DNA sample taking



Atomic Detectives - Summary

Nuclear forensics

- Discipline between science, law enforcement,
- Uses systematic approach for analysis and attribution
- Benefits from Reference Data
- Provides clues on the origin of the material
- Assures sustainability in combating illicit trafficking
- Calls for International Co-operation
- Methodology applicable in other areas

ITWG Nuclear Forensics

IAEA International Atomic Energy Agency